APPENDIX C1
AQUATIC RESOURCES METHODOLOGY

C1.1 INTRODUCTION

Appendix C1 describes the processes and bases used to evaluate the No-Project Alternative, the Proposed Project, and the Federal Energy Regulatory Commission (FERC) Staff Alternative and their potential effects on aquatic and fisheries resources. Implementation of any of the alternatives is anticipated to produce two distinct types of effects: (1) direct effects related to construction activities or changes in Oroville Facilities operations; and (2) indirect effects related to changes in hydrologic conditions. The potential effects related to changes in hydrologic conditions may affect environmental resources beyond the project study area and are addressed under the cumulative analysis (see Section 6.2, Cumulative Impacts).

Qualitative assessments were completed to evaluate potential effects on aquatic resources. Qualitative analyses were conducted based on a combination of previous hydrologic and water temperature modeling for the Preliminary Draft Environmental Assessment (PDEA), literature reviews, study plan results, and the best professional judgment and experience of qualified individuals. These qualitative analyses examined potential effects associated with all of the following:

- Changes in flow regimes and associated potential changes in water temperatures;
- Fish interactions (e.g., competition for food or habitat, genetic introgression, predation);
- Fisheries resources management (stocking programs and disease management); and
- Potential effects on Chinook salmon spawning segregation, macroinvertebrate populations, woody debris distribution, gravel recruitment, and water quality criteria for aquatic life in relationship to aquatic resources and habitat quality.

A detailed quantitative analysis of effects on aquatic resources was not conducted for this draft environmental impact report (DEIR) based on the discussion included in Section 5.4.3, Aquatic Resources, Method of Analysis. A quantitative analysis of hydrologic and water temperature conditions would only reflect those changes applicable to the “initial new license operating period” which includes use of the River Valves to meet hatchery water temperature requirements, and additional minimum instream flows and other temperature control actions to meet water temperature objectives for the lower Feather River. During the initial new license operating period water temperature targets are the same or more beneficial to coldwater species as those under Existing Conditions. The modeling reflects operations for about the next ten years because specific facilities modifications to be implemented in future years (e.g., River Valves improvements, Palermo Canal improvements, or Hyatt intake extension) are not yet known. Therefore, it is not possible to model conditions associated with project operations including unknown, potential future facilities modifications. Potential facilities modifications will be analyzed in greater detail in a subsequent feasibility study and future environmental documentation.

C1.2 QUALITATIVE EVALUATION OF OPERATIONS-RELATED EFFECTS

C1.2.1 Operations-Related Effects on Reservoir Fish species

Implementation of the No-Project Alternative, the Proposed Project, or the FERC Staff Alternative could result in alterations to storage volumes and water surface elevations within Oroville Facilities reservoirs. Day-to-day operations and changes in runoff patterns could result in changes in the timing and magnitude of reservoir drawdown. The resulting fluctuation of Oroville Facilities reservoirs could potentially affect recreationally important reservoir fish species of primary management concern. Methods used to determine potential effects on reservoir fish species within Lake Oroville and other project reservoirs are discussed below.

The analysis of aquatic biological resources focuses on how reductions and fluctuations in the coldwater pools and water surfaces of Oroville Facilities reservoirs could affect coldwater and warmwater fish habitat and aquatic resources. For example, the seasonal timing and rate of reductions in reservoir water surface elevation during the black bass spawning period determines the proportion of bass nests that potentially could be dewatered. Bass populations reportedly require approximately 60 percent nest success to remain self-sustaining (Friesen 1998; Goff 1996; Hunt and Annett 2002; Hurley 1975; Knotek and Orth 1998; Kramer and Smith 1962; Lukas and Orth 1995; Neves 1975; Philipp et al. 1997; Raffetto et al. 1990; Steinhart 2004; Turner and MacCrimmon 1970). Reservoir coldwater pool volume is affected by project releases and coldwater pool is required for coldwater fish habitat. Changes in the proportion of available coldwater pool volume are an indicator of the potential changes in the amount of available coldwater fish habitat. Potential changes in seasonal timing and fluctuations of water surface elevations and coldwater pool availability are evaluated qualitatively based on proposed operational changes under the No-Project Alternative, Proposed Project, and FERC Staff Alternative.

Extensive sediment deposits, or sediment wedges, were identified in all four major tributaries of the Feather River at approximately 720 feet above mean sea level (msl) and below during field investigations conducted during October and December 2002 (DWR 2004a). Sediment wedges are subject to periodic exposure events when the reservoir surface elevation drops below the elevations at which the wedges occur. Such exposure events may inhibit or prohibit the movement of fish from the reservoir to tributaries upstream of Lake Oroville. Currently, the upper Feather River watershed is reportedly producing high sediment loads because of accelerated erosion. The Natural Resources Conservation Service estimated that 90 percent of the erosion in the 1,209-square-mile study area was accelerated erosion (NRCS 1998). Accelerated erosion is a soil loss greater than natural geologic conditions, which can reduce reservoir capacity, degrade water quality, and harm fish and wildlife.

The presence or absence of exposed sediment wedges is a potentially important factor to be considered in the analysis of project operations on aquatic resources. If sediment wedges are exposed during large portions of the upstream migration periods of stocked salmonid species, access to upstream spawning habitat could be affected substantially. In contrast, if the sediment wedges are not exposed for large portions of the migration periods of stocked salmonids, it is likely that upstream migration would not be affected substantially by sediment wedge exposure. The absence of exposed sediment wedges may allow for the undesirable upstream migration of stocked salmonid species or warmwater species currently in Lake Oroville. Upstream migration of stocked salmonid species could result in competition for spawning and juvenile rearing habitat with resident native salmonids or genetic introgression among stocks if the same species are stocked (e.g., rainbow trout). Upstream migration of warmwater species (e.g., black bass) could potentially increase predation rates on native resident juvenile salmonids.

As reported in Study Plan (SP) G1, sediment wedges are dynamic and mobilize differently based on different hydrologic conditions in tributaries and reservoirs. If the reservoir elevation is greater than the uppermost elevation of the wedge, lentic conditions predominate and wedge material does not move appreciably. If the reservoir elevation is lower than the wedge material, fluvial conditions predominate and typical stream processes transport wedge materials downstream. Because of the dynamic nature of the sediment wedges in the upper Feather River/Lake Oroville interface, it is difficult to assess the frequency, magnitude, and duration of sediment wedge exposure over time and its resulting effect on fisheries interactions in the reservoir and upstream tributaries. Further, the ability to determine that an exposed sediment wedge is a potential fish migration barrier depends on a number of conditions that are variable and, thus, cannot be reliably predicted. Therefore, a qualitative evaluation of the potential effects of sediment wedge exposure and resulting fish migration conditions was performed for the No-Project Alternative, the Proposed Project, and the FERC Staff Alternative.

C1.2.1.1 Warmwater Reservoir Fish Species of Primary Management Concern

Warmwater fish species present in Lake Oroville, including largemouth bass, smallmouth bass, spotted bass, green sunfish, crappie, and catfish, use the warm upper layer of the reservoir and nearshore littoral habitats throughout most of the year. Therefore, seasonal changes in reservoir storage, as they affect reservoir water surface elevation, and the rates at which the water surface elevation changes during specific periods of the year, can directly affect the reservoir's warmwater fisheries resources. Reduced water surface elevations can potentially reduce the availability of nearshore littoral habitats used by warmwater fish for spawning and rearing, thereby reducing spawning and rearing success and subsequent year-class strength. In addition, decreases in reservoir water surface elevation during the primary spawning period for warmwater fish nest building may result in reduced initial year-class strength as a result of nest "dewatering." Potential effects of project operations on warmwater fish species of management concern are evaluated qualitatively based on changes in reservoir operations associated with implementation of the No-Project Alternative, Proposed Project, and the FERC Staff Alternative.

Criteria for reservoir elevation increases (nest flooding events) have not been developed by the California Department of Fish and Game (DFG). Because of overall reservoir fishery benefits (e.g., an increase in the availability of littoral habitat for warmwater fish rearing), greater reservoir surface elevations that would be associated with rising water levels would offset negative effects caused by nest flooding (Lee 1999). Therefore, the effects on spawning warmwater fishes from increases in reservoir water surface elevations are not addressed for reservoir fisheries. A qualitative assessment of the availability of littoral habitat for juvenile bass rearing was conducted for both Lake Oroville and Thermalito Afterbay. Additionally, a qualitative assessment was conducted to evaluate the potential effects associated with changes in reservoir surface elevations, drawdown rate and timing, and habitat enhancement programs on stocking and fish interactions (competition for food and habitat, genetic introgression, predation, and disease).

C1.2.1.2 Coldwater Reservoir Fish Species of Primary Management Concern

During the period when Lake Oroville is thermally stratified (April through November), coldwater fish (e.g., salmonids) within the reservoir reside primarily within the reservoir's metalimnion and hypolimnion, where water temperatures remain suitable. Reduced reservoir storage during this period could reduce the reservoir's coldwater pool volume, thereby reducing the quantity of potential habitat available to coldwater fish species. The size of the reservoir coldwater pool generally decreases as reservoir storage decreases, although not always in direct proportion because of the influence of reservoir basin morphometry and management of water temperature releases from the reservoir.

The water temperature criterion used in the analysis of potential effects on coldwater fish habitat is based on the most stringent criteria recommended by the U.S. Environmental Protection Agency (USEPA) for protection of aquatic life and for growth of adult and juvenile salmonids. The criterion chosen is based on the weekly maximum average water temperature because no monthly criterion is recommended by USEPA for protection of aquatic life. USEPA suggests two types of criteria for water temperature for coho salmon:

- Maximum weekly average water temperature for growth of juvenile and adult coho salmon (18 degrees Celsius (°C) or 64.4 degrees Fahrenheit (°F)); and

- Maximum weekly average water temperature for survival of juvenile and adult coho salmon (24°C or 75.2°F) (USEPA 2002).

Eighteen degrees Celsius was chosen as the water temperature defining the upper layer of the usable coldwater salmonid habitat for two reasons: (1) 18°C (64.4°F) was a more protective estimate than the 24°C (75.2°F) water temperature criterion for survival of juvenile and adult coho salmon; and (2) of all the salmonids for which specific criteria are recommended, coho salmon had the most stringent water temperature recommendations. Additionally, coho salmon have recently been stocked in Lake Oroville. For the purpose of this analysis, water with a temperature less than 18°C (64.4°F) was considered usable coldwater salmonid habitat.

Coldwater fish habitat also requires dissolved oxygen (DO) concentrations at or above 6.5 milligrams per liter (mg/L), based on USEPA criteria for sustainable coldwater fisheries, as well as a food base appropriate for coldwater fisheries. No characterizations of DO or food base are available from prior project modeling results, so the relative proportion of change in the coldwater pool volume was used as an indicator of the potential change in the quantity of coldwater fish habitat. The potential for substantial reductions in reservoir storage with implementation of the No-Project Alternative, Proposed Project, and FERC Staff Alternative were evaluated qualitatively.

The water temperature regime for Thermalito Afterbay is dynamic and is controlled by Oroville Facilities, the temperature of water released from Thermalito Pumping-Generating Plant, peaking and pumpback operations, and rates of agricultural diversions to the FRSA and Thermalito Afterbay releases into the Feather River. Section 4.2 of the DEIR, Surface Water Quantity and Quality, provides information relating to the characteristics of coldwater conditions in Thermalito Afterbay. Project-related changes were qualitatively assessed for their potential effects on coldwater fish habitat in Thermalito Afterbay.

Additionally, qualitative assessments were conducted of potential changes in reservoir surface elevations, drawdown rate and timing, and effects of habitat enhancement programs on stocking and fish interactions (competition for food, habitat, introgression, predation, and disease).

C1.2.2 Flow-Related Effects on Lower Feather River Fish Habitat

Changes in flow affect water surface elevations based on site-specific stage discharge relationships in the river. Changes in water surface elevations, in turn, potentially change the suitability of habitat with respect to water depth for species with minimum or maximum water depth requirements, inundation of habitat, and water velocity for some fish species and life stages.

Flows in the Low Flow Channel (LFC) of the Feather River, which extends from the Fish Barrier Dam to the Thermalito Afterbay Outlet, currently are governed by a 1983 agreement between the California Department of Water Resources (DWR) and DFG (DWR 1983). The agreement specifies that DWR "…shall release into the Feather River from the Thermalito Diversion Dam for fishery purposes a flow of 600 cfs [cubic feet per second]…" (DWR 1983). With implementation of the Proposed Project or the FERC Staff Alternative, flow in this reach of the river would increase above the basis of comparison, 600 cfs. Total releases to the lower Feather River below the Thermalito Afterbay Outlet (i.e., High Flow Channel (HFC)) would not change, nor would the minimum flow requirements for the HFC change. As a result of the potential flow changes in the LFC with implementation of the Proposed Project or the FERC Staff Alternative, the qualitative analyses evaluate the LFC and HFC separately for flow-related effects on aquatic resources. See Chapter 3.0, Description of Existing Facilities and Operations, the Proposed Project, and Alternatives, for additional information describing flows.

Qualitative analyses were conducted to determine the relationship between flow changes and the quantity and distribution of anadromous salmonid spawning habitat in the LFC. These analyses were based on site-specific stage discharge relationships developed to characterize the availability of habitat for the spawning life stage of Chinook salmon and steelhead. Results from the physical habitat simulation (PHABSIM) model were used in the effects analyses to evaluate the relationship of flows to availability of spawning habitat for Chinook salmon and steelhead (DWR 2004b).

Additionally, for each of the alternatives, qualitative analyses of flow changes and their potential effects were conducted for fish species and life stages for which specific, quantified flow-habitat availability relationships have not been established. Qualitative analyses of flow changes occurring with implementation of the alternatives were conducted to characterize the types of effects that could potentially occur on the relative quality and quantity of fish habitat for all of the following fish species and life stages:

- American shad adult immigration and spawning;
- Chinook salmon adult immigration and holding;
- Chinook salmon juvenile rearing and downstream movement;
- Steelhead/rainbow trout adult immigration and holding/residence;
- Steelhead/rainbow trout juvenile rearing and downstream movement;
- Steelhead smolt emigration; and
- Striped bass adult spawning.

Flow changes were evaluated qualitatively to determine the relative changes in habitat with respect to water depth, water velocity, and the amount of inundated habitat area compared to the known distribution and relative abundance for each species and life stage evaluated.

C1.2.3 Water Temperature–Related Effects on Lower Feather River Fish Habitat

Current criteria for managing water temperatures in the lower Feather River were established in the 1983 agreement between DFG and DWR, which stated that: (1) water temperatures below the Thermalito Afterbay Outlet must be suitable for fall-run Chinook salmon after September 15; (2) water temperatures below the Thermalito Afterbay Outlet must be suitable for American shad, striped bass, and other warmwater fish from May through August; and (3) daily average temperatures for water supplied to the Feather River Fish Hatchery must not exceed the following:

- 60°F from June 16 through August 15;
- 58°F from August 16 through August 31;

- 56°F from June 1 through June 15;
- 55°F from December 1 through March 31, and May 16 through May 31;
- 52°F from September 1 through September 30; and
- 51°F from October 1 through November 30, and April 1 through May 15.

A deviation of plus or minus 4°F for these average daily water temperatures is allowed between April 1 through November 30 (DWR 1983).

With implementation of the No-Project Alternative, the current water temperature criteria for management of aquatic resources in the lower Feather River would remain in place. The Proposed Project and FERC Staff Alternative would modify the water temperature targets at Robinson Riffle. No alternative would modify hatchery water supplies such that water temperature management constraints for the lower Feather River would change. However, flow changes in the LFC from 600 cfs (Existing Conditions and No-Project Alternative) to 700 cfs (Proposed Project) or 800 cfs (FERC Staff Alternative) also would alter the water temperature regime in the lower Feather River. See Chapter 3.0, Description of the Existing Facilities and Operations, the Proposed Project, and Alternatives, for further definition of the water temperature management and flow standards proposed under the No-Project Alternative, the Proposed Project, and the FERC Staff Alternative.

The first step in developing the qualitative analysis for water temperature effects was to determine the current location and distribution of potentially suitable fish habitat for each species and life stage selected for analysis. Suitable habitat requirements for each species and life stage evaluated were defined using the matrices from SP-F3.2, Task 2, Fish Life History and Habitat Requirement, which were produced from a comprehensive literature review, as well as from the results of other study plan reports. Fish habitat component requirements included mesohabitat (generalization of hydraulic conditions, i.e., glide, pool, riffle, run), substrate type, and water depth. Fish habitat component distribution in the lower Feather River was mapped and presented in SP-G2 and was used as the basis of the SP-F3.2, Task 4, Comparison of Fish Distribution to Fish Habitat in the Lower Feather River report. Appendix G-AQUA1, Affected Environment of the PDEA, provides summaries of the aquatic resources study plan reports, and Section C1.4, Lower Feather River Fish Species of Primary Management Concern, below, identifies habitat component requirements for specific species and life stages.

Because cooler water temperatures in the lower Feather River are expected with implementation of either the Proposed Project or the FERC Staff Alternative, the second step in the qualitative analysis of potential water temperature effects was to evaluate potential effects of cooler water temperatures on all fish species of management concern and their associated life stages. Potential changes in the quantity and quality of fish habitat with implementation of the No-Project Alternative, Proposed Project, and the FERC Staff Alternative were evaluated qualitatively based on proposed changes in flows and water temperatures in the LFC.

C1.3 QUALITATIVE FISH HABITAT COMPONENT EVALUATIONS

C1.3.1 Chinook Salmon Spawning Segregation

Blocking upstream migration has eliminated the spatial separation between spawning fall-run and spring-run Chinook salmon. Reportedly, spring-run Chinook salmon migrated to the upper Feather River and its tributaries from mid-March through the end of July (DFG 1998b). Fall-run Chinook salmon reportedly migrated later and spawned in lower reaches of the Feather River than spring-run Chinook salmon (Yoshiyama et al. 2001). Restricted access to historic spawning grounds currently causes spring-run Chinook salmon to spawn in the same lowland reaches that fall-run Chinook salmon use as spawning habitat. The overlap in spawning site locations, combined with a slight overlap in spawning timing (Moyle 2002) with temporally adjacent runs, may be responsible for inbreeding between spring-run and fall-run Chinook salmon in the lower Feather River (Hedgecock et al. 2001).

The Proposed Project and the FERC Staff Alternative include actions that would address effects on anadromous fishes caused by the blockage of upstream passage by the Oroville Facilities. In both scenarios, fish segregation weirs would be installed downstream of the Fish Barrier Dam to segregate spring-run and fall-run Chinook salmon. The reason for implementing this action is that spring-run Chinook salmon migrate upstream earlier during the year than fall-run Chinook salmon, which allows the runs to be segregated by allowing fish passage on a temporal basis. The effects of this action were evaluated on a qualitative basis using historic information on escapements, information collected during preparation of the SP-F10 Study Plan Report, and various agency reports on Chinook salmon run timing in the Feather River.

C1.3.2 Macroinvertebrate Populations

Aquatic macroinvertebrates consist primarily of insects, snails, clams, shrimp, and zooplankton. The current status of macroinvertebrate populations in the project study area was described in the interim and final reports for SP-F1, Task 1, Evaluation of Project Effects on Non-Fish Aquatic Resources, and is summarized in Section G-AQUA1.1 of Appendix G-AQUA1 of the PDEA. Construction of Oroville Dam changed the hydrologic cycle of the lower Feather River. These changes likely affected invertebrate life cycles and communities that evolved over time. Fluctuating reservoir surface elevations, controlled flows, and less frequent scouring events likely have affected non-fish aquatic resources. Macroinvertebrates and plankton communities may be directly affected by future changes in project operations that affect the amount of surface water, flow rates, water temperatures, or water quality in the project area.

Aquatic macroinvertebrates and plankton are important components of the biological food web in any aquatic ecosystem. Many invertebrate species are important to the recycling of nutrients in aquatic systems. They also are an important food source for fish, and their community structure and diversity are important factors in determining general ecosystem conditions. Stream health generally is determined by macroinvertebrate species diversity or through groupings at higher taxonomic levels.

Negative effects from environmental shifts or anthropogenic effects are shown by decreasing species diversity, organism size, or changes in taxa composition (Erman 1996).

As a basis for this assessment, projected physical and chemical changes associated with future project operations were compared with ecological requirements for macroinvertebrates and plankton populations within waters affected by the project. A qualitative assessment of potential effects was conducted to evaluate the general direction of such potential effects. Professional judgment was used to qualitatively assess effects, as supported by biological information cited herein.

C1.3.3 Woody Debris Recruitment

The Oroville Facilities prevent the recruitment of large woody debris (LWD) from the upstream reaches of the Feather River and its tributaries to the lower Feather River below Oroville Dam. Current sources of LWD in the lower Feather River are the riparian zone along the river, occasional inputs from orchards adjacent to the river, and other tributaries flowing into the lower Feather River. Moderated flow regimes in the lower Feather River also have reduced recruitment of LWD. In addition, current LWD recruitment is different in quality than under pre-dam conditions because the origin of the pre-dam wood would have been from mixed hardwood and coniferous forests not present in riparian zones downstream of Lake Oroville.

LWD is an important component of geomorphic processes and ecological functions in rivers and streams. Woody debris enhances the complexity of fish habitat and may redirect streamflow to create pools that serve as holding areas for anadromous salmonids. In addition, decaying LWD provides a source of nutrients for aquatic organisms. Generally, the influence of LWD on stream geomorphology and ecology varies with stream size (Lassettre and Harris 2001). On larger streams such as the Feather River the effects of LWD on geomorphic processes are limited, but it still performs important ecological functions. In these larger streams, LWD can provide shelter for salmonids, and when associated with secondary channels, it contributes to the quality and diversity of juvenile rearing habitat.

LWD supplementation programs for the lower Feather River are included under the Proposed Project and the FERC Staff Alternative. Effects of LWD supplementation were evaluated qualitatively for the Proposed Project and the FERC Staff Alternative using a literature review, and comparisons were made between the current quantity, distribution, and habitat function of LWD in the lower Feather River and fish habitat quality.

C1.3.4 Gravel/Sediment Recruitment

Chinook salmon, steelhead, and river lamprey use riffles and runs with a gravel substrate for spawning. Females of each species construct nests (redds) in the substrate by creating a shallow depression in the gravel. Eggs are then deposited in the depression while males release sperm over the eggs for fertilization. Next, eggs are covered with a layer of gravel where they incubate, and juveniles emerge from the gravel at a later date depending on egg incubation time required for the species. Because the incubating eggs require a constant supply of oxygenated water, gravel is the required substrate.

Spawning habitat for anadromous salmonids below Oroville Dam has been affected by changes to the geomorphic processes caused by several factors, including hydraulic mining, land use practices, construction of flood management levees, regulated flow regimes, and construction and operation of Oroville Dam. The dam blocks sediment recruitment from the upstream areas of the watershed. In the lower reaches of the river, levees and bank armoring prevent gravel recruitment. Periodic flows of sufficient magnitude to mobilize smaller sized gravel from spawning riffles result in armoring of the remaining substrate. DWR (1996) evaluated the quality of spawning gravels in the lower Feather River based on bulk gravel samples and Wolman surface samples obtained during spring 1996. The study concluded that the worst scoured areas had an armored surface layer too coarse for spawning salmonids. Additionally, much of the streambed substrate in the reach from the Fish Barrier Dam to the Thermalito Afterbay Outlet is composed of large gravel and cobble, which is too large for construction of spawning redds for Chinook salmon and steelhead. This reach of the lower Feather River is by far the most intensively used spawning habitat of the river for salmon and steelhead.

Gravel supplementation is a proposed measure under both the Proposed Project and the FERC Staff Alternative. Both the Proposed Project and the FERC Staff Alternative would implement rip and raking of selected armored stream bottoms, in addition to the placement of gravel at targeted sites in the river reach between the Fish Barrier Dam and the Thermalito Afterbay Outlet. Effects of the Gravel Supplementation and Improvement Program on the quality of fish habitat were evaluated qualitatively for both alternatives using a literature review and professional judgment.

The Proposed Project and the FERC Staff Alternative include actions to improve the quality and quantity of salmonid spawning gravel, as well as to potentially create new spawning habitat. The effects of superimposition on egg mortality and alevin survival were qualitatively evaluated for the Proposed Project and the FERC Staff Alternative based on changes in habitat quality, quantity, and distribution in relation to salmonid spawning habitat use characteristics.

C1.3.5 Channel Complexity

For purposes of this analysis, channel complexity refers to the diversity of geomorphologic features in a particular river reach. Such features include undercut stream banks, meanders, point bars, side channels, backwaters, etc. Regulation of the lower Feather River by the Oroville Facilities has changed both streamflow and sediment discharge. As discussed in the PDEA, more than 97 percent of the sediment is trapped in the reservoir, resulting in sediment starvation downstream. Attenuation of peak flows, decreased winter flows, increased summer flows, and changes to historic flow frequencies have led to a general decrease in channel complexity downstream of Oroville Dam.

Because several fish species of management concern and different life stages of these species occur in the lower Feather River, a diversity of habitat types is required. Increases in channel complexity lead to an increase in habitat diversity and habitat quality. Increases in channel complexity are proposed in several different actions under the Proposed Project and the FERC Staff Alternative. These actions include gravel and LWD supplementation, as well as the restoration and creation of side channels to increase spawning and juvenile rearing habitat for steelhead and Chinook salmon. Effects of increasing channel complexity were evaluated qualitatively for the Proposed Project and the FERC Staff Alternative using a literature review and professional judgment.

C1.3.6 Water Quality Criteria for Aquatic Life

Water quality, as it affects aquatic life in the project area, was evaluated in the SP-F3.2, Task 1, 4, 5 Report, Final Report—Comparison of Fish Distribution to Fish Habitat in the Lower Feather River, which is summarized in Section G-AQUA1.4.1 of Appendix G-AQUA1 of the PDEA. DO concentrations were evaluated separately in the report but are included in the discussion of water quality effects on aquatic life in this appendix. The National Ambient Water Quality Criteria (NAWQC) is the applicable regulatory standard that is calculated by USEPA. These criteria represent half the value of toxic substance concentration that would cause 50 percent mortality in 5 percent of a briefly exposed population (USEPA 2002). In addition to NAWQC criteria, on May 18, 2000, USEPA published 40 Code of Federal Regulations (CFR) 131, Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California, generally known as the California Toxics Rule (CTR). Section 5.2.2 of the DEIR, Surface Water Quality, provides additional information on these water quality standards.

USEPA reports that the 30-day mean water column DO concentration required for the protection of adult life stages of coldwater fish species is 6.5 mg/L (USEPA 2002). USEPA also reports criteria for a single-day minimum to be 4.0 mg/L and 7-day mean minimum to be 3.0 mg/L; however, both of these criteria are less protective than the 30-day mean value provided by USEPA as a minimum DO concentration suitable for coldwater aquatic life (USEPA 2002).

Although no actions included in the No-Project Alternative, Proposed Project, or the FERC Staff Alternative directly target water quality in the project area as it pertains to aquatic species, construction activities related to mitigation and enhancement measures within and adjacent to the Oroville Facilities and the lower Feather River could result in short-term impacts to water quality. Water quality effects on aquatic life were evaluated qualitatively for the Proposed Project and the FERC Staff Alternative using a literature review and professional judgment. Water quality–related effects associated with instream construction activities are included in Section 5.2.2, Surface Water Quality, of the DEIR.

C1.3.7 Lake Oroville Warmwater Fishery Habitat Improvement

Both the Proposed Project and the FERC Staff Alternative include provisions for habitat improvements in Lake Oroville benefiting warmwater species. Although these provisions currently are not explicitly defined, they may include providing cover for juvenile black bass, spawning structures for catfish, and planting of native plants within the reservoir's fluctuation zone. Because potential Lake Oroville warmwater fishery habitat improvements are not explicitly defined at this time, they are not evaluated in this document.

C1.3.8 Construction and Recharge of Brood Ponds

Both the Proposed Project and the FERC Staff Alternative include provisions for establishing four waterfowl brood ponds in the Thermalito Afterbay. Although this action is targeted towards benefiting waterfowl, there will be an indirect benefit to warmwater fish species in the Thermalito Afterbay during the primary waterfowl brooding season (April 15 through July 31) by providing additional juvenile rearing habitat and reducing surface fluctuations in those portions of the Thermalito Afterbay where brood ponds are constructed. Because the locations and sizes of the brood ponds are not explicitly defined at this time, they will not be evaluated in this EIR.. However, because construction may result in minor temporary adverse effects, brood pond construction will likely require future analysis and environmental documentation.

C1.3.9 Spring-run Chinook Salmon and Steelhead Habitat Expansion Program

The Proposed Project and the FERC Staff Alternative include a habitat expansion program benefiting spring-run Chinook salmon and steelhead in the Sacramento River watershed. The specific goal of the program is to expand spawning, rearing, and adult holding habitat to accommodate an estimated net increase of 2,000 to 3,000 spawning Spring-run Chinook salmon within the Sacramento River watershed, but not necessarily within the FERC Project boundary. Although the focus of the program is on Spring-run Chinook salmon, this new habitat also would accommodate steelhead.

Actions undertaken to implement this program may include removal of migration barriers, deployment of LWD or gravel to enhance habitat, facilities for fish passage, and riparian zone improvements. Under the proposed habitat expansion program, the National Marine Fisheries Service (NMFS) will be required to approve any proposed measures prior to implementation. Because the specifics of any projects included as part of the program have not yet been developed, no evaluation of this program is included in this EIR.

C1.3.10 Potential Future Facility Modifications

Settlement Agreement (SA) Article 108 calls for future facilities modifications for improving water temperatures in the LFC and HFC to protect anadromous fishes over the term of the FERC license. Potential facility modifications include:

- Palermo Canal improvements;

- Hyatt Intake extension;
- River valve replacement;
- Canal around Thermalito Afterbay;
- Canal through Thermalito Afterbay;
- Thermalito Afterbay temperature curtain; and
- Alternate Thermalito Afterbay Outlet and channel.

Each of these potential modifications is described in Section 3.3, Description of Alternatives under Consideration, in the DEIR. A report entitled Reconnaissance Study of Potential Future Facility Modifications was completed per the terms of the SA, and submitted to stakeholders and FERC in January 2007. A more in-depth feasibility study of selected measures will be initiated once the new FERC license is issued. For purposes of this DEIR, since plans are only conceptual in nature at this early stage of study, each of the potential facility modifications is evaluated qualitatively for each fish species of management concern.

C1.4 LOWER FEATHER RIVER FISH SPECIES OF PRIMARY MANAGEMENT CONCERN

Changes in Oroville Facilities operations during the initial new license operating period could potentially alter seasonal drawdown rates in Lake Oroville and, thus, lower Feather River flows and water temperatures, which could change the relative availability of habitat for fish species present in the lower Feather River. The lower Feather River is used by a number of fish species of primary management concern, primarily as habitat during one or more of their life stages, but also as a migration corridor to upstream habitat in other river systems (e.g., the Yuba River). For these reasons, species-specific effect assessments were conducted for the following species of primary management concern:

- Fall-run Chinook salmon;
- Spring-run Chinook salmon;
- Steelhead/Rainbow trout;
- American shad;
- Black bass (largemouth bass, smallmouth bass, redeye bass, and spotted bass);
- Green sturgeon;
- Hardhead;

- River lamprey;
- Sacramento splittail; and
- Striped bass.

Implementation of the No-Project Alternative, the Proposed Project, or the FERC Staff Alternative could potentially alter lower Feather River water temperatures. Proposed changes in Feather River water temperature targets as outlined in the SA are oriented primarily to meet coldwater fisheries water temperature requirements for salmonids. As such, the salmonid fish species of management concern are the primary focus of the evaluations of the alternatives with regard to water temperature. Moreover, thermal requirements of Chinook salmon and steelhead are generally similar; and the NMFS Biological Opinion on interim operations of the Central Valley Project (CVP) and State Water Project (SWP) on federally listed threatened Central Valley spring-run Chinook salmon and Central Valley steelhead (Operations Criteria and Plan [OCAP] Biological Opinion [BO], NMFS 2002) has established quantitative water temperature criteria for the lower Feather River at the Feather River Fish Hatchery and for the LFC (monitored near Robinson Riffle [below river mile (RM) 62]) to protect spring-run Chinook salmon and steelhead. Therefore, the assessment methodologies for this DEIR focus primarily on the Chinook salmon and steelhead life stages. The species and life stage–specific flow and water temperature assessment methodologies for the Feather River effect analyses are discussed in the following sections.

C1.4.1 Spring- and Fall-run Chinook Salmon

Potential fisheries effects in the two reaches of the lower Feather River (LFC and HFC) were evaluated separately because of the differences in the characteristics of the flow regimes, and because each reach provides different values to the different life stages of anadromous salmonids (adult immigration and holding, adult spawning and embryo incubation, and juvenile rearing and downstream movement). Detailed descriptions of spring-run and fall-run Chinook salmon life stages and time periods are provided in Section 4.4.2, Fish Species Overview, of the DEIR.

C1.4.1.1 Flow-Related Effects

Because of the differences in the proposed changes in flow in the LFC and HFC for the Proposed Project and the FERC Staff Alternative, the reaches were evaluated separately for flow-related effects on aquatic resources. Chapter 3.0, Description of Existing Facilities and Operations, the Proposed Project, and Alternatives, provides additional information describing flows.

Site-specific flow-related effects on the spawning and egg incubation life stage of Chinook salmon and steelhead were determined by analyzing the results of Instream Flow Incremental Methodology (IFIM) studies (DWR 2004b). IFIM is a decision-support analytical tool designed to aid resources managers and stakeholders in determining the effects of different water management alternatives (Bovee et al. 1998), and currently is reported to be the most widely used and defensible technique worldwide for assessing instream flow requirements for fisheries purposes. IFIM includes a wide variety of analytical tools of varying complexity to address multiple aspects of riverine dynamics and ecology, including sophisticated computer models such as PHABSIM. PHABSIM results were used to quantify changes in available habitat between alternatives.

In general, three main components are needed to obtain PHABSIM results. First, hydraulic data along with substrate and cover data characterizing the conditions in the river are required. The data are subsequently used to create hydraulic models (i.e., models that describe the movement and force of water), which evaluate and predict habitat variables (e.g., water depth, water velocity, substrate, and cover) at a selected study site throughout a range of flows. The hydraulic models, in turn, are combined with habitat suitability criteria (HSC) models that evaluate the relative incremental utility of habitat attributes to each life stage and species under consideration. HSC curves are derived from observations of hydraulic and physical habitat variables associated with each species and life stage being analyzed (Bovee et al. 1998). PHABSIM results are an index of the quantity and quality of the relative amount of fish habitat by species and life stage and typically are referred to as Weighted Usable Area (WUA), or sometimes relative suitability index (RSI) values.

The results of the PHABSIM model calculations, expressed as WUA, were used in the quantification of habitat changes associated with flow changes among alternatives in the PDEA and are used in this DEIR. Therefore, a brief explanation of WUA is necessary. WUA is a relative indicator of suitability and, as such, is an index representing available habitat area. WUA does not represent actual physical area available for use by the species. Because WUA is an index of habitat suitability, it cannot be directly related to the number of individuals that could occupy the lower Feather River under different flow regimes. WUA does, however, indicate the differences in relative habitat suitability among alternatives. Figures C1.4-1 and C1.4-2 show the Chinook salmon WUA index curves for the LFC and HFC, respectively.

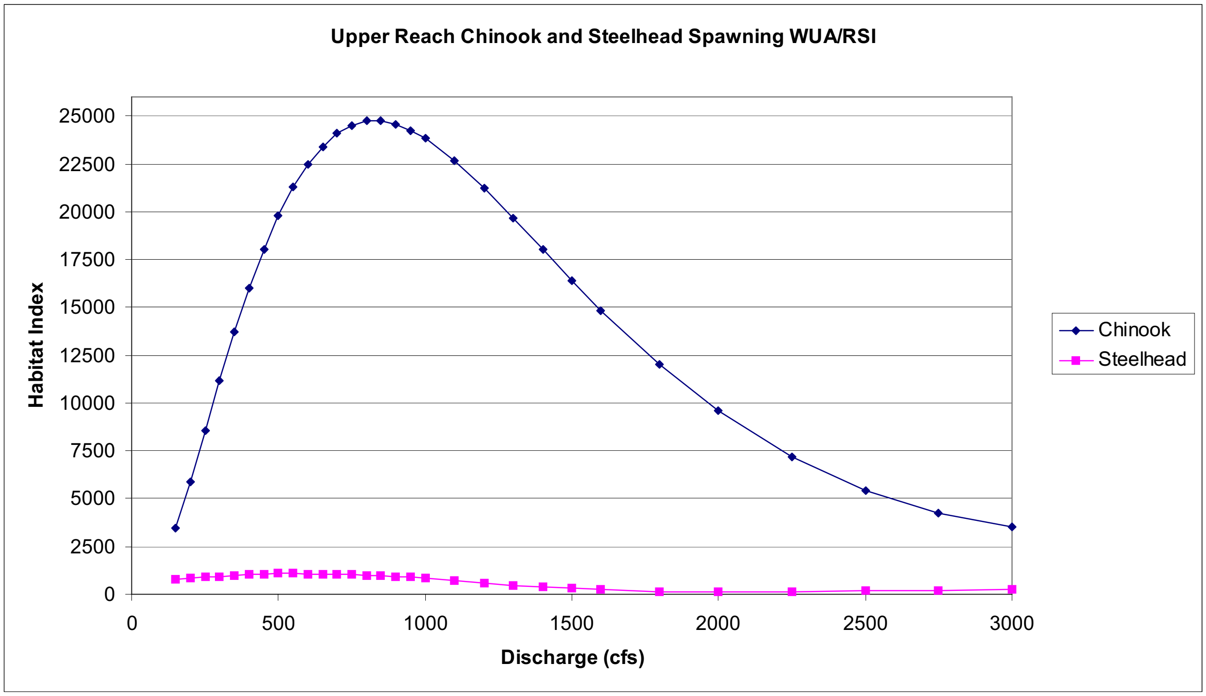

Figure C1.4-1. WUA/relative suitability index for Chinook salmon and steelhead spawning in the LFC of the lower Feather River.

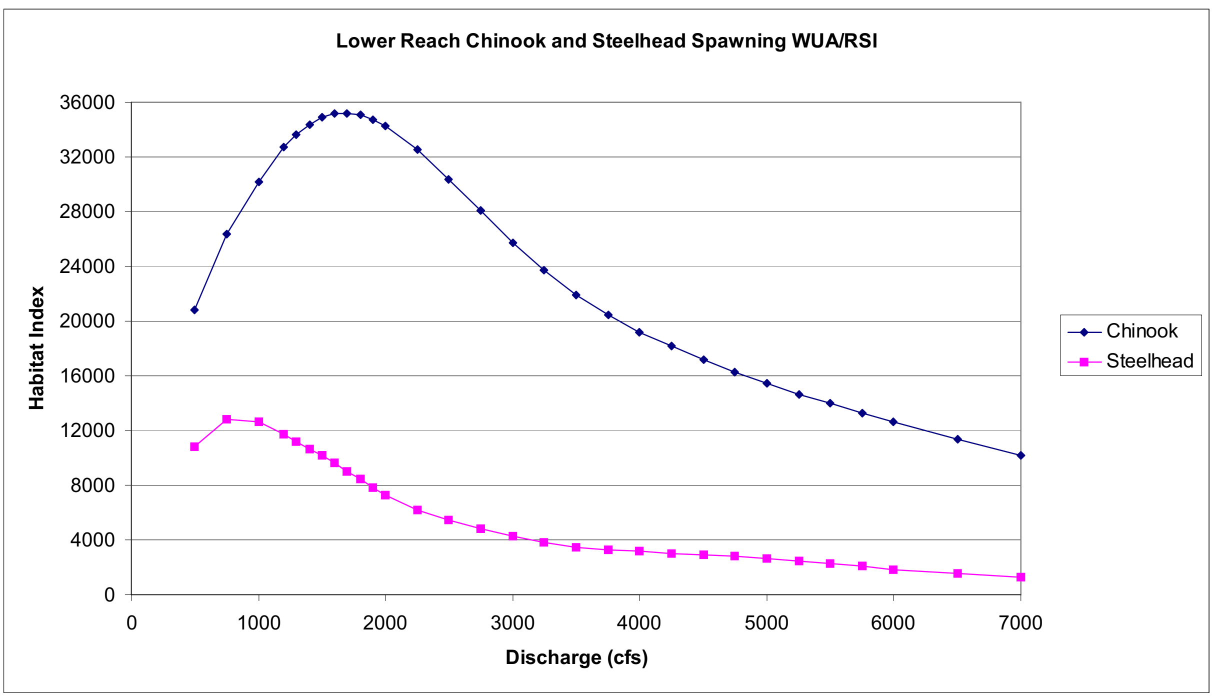

Figure C1.4-2. WUA/relative suitability index for Chinook salmon and steelhead spawning in the HFC of the lower Feather River.

Qualitative analysis of flow-related effects on fisheries and aquatic resources in the LFC and the HFC was completed. To assess flow-related effects on spring- and fall-run Chinook salmon spawning life stages in the lower Feather River, PHABSIM results at flows associated with each alternative were compared to those associated with the basis of comparison.

Detailed descriptions of the methodology associated with the IFIM studies conducted on the lower Feather River, including descriptions of the PHABSIM model and HSC curves used for calculation of Chinook salmon spawning WUA, are available in the Final Report for SP-F16 (see Section G-AQUA1.10 of Appendix G-AQUA1 of the PDEA).

Analysis of available spawning area using PHABSIM model results does not provide information regarding the potential for stage reductions during the embryo incubation portion of the adult spawning and embryo incubation life stage. However, because flows under the alternatives would remain constant in the LFC, and fluctuate within the minimum flow and maximum flow agreed upon by DFG and DWR in the HFC, further analysis of the effects of flow fluctuations in the LFC or HFC on embryo incubation is unnecessary.

Flow changes and flow fluctuations associated with the alternatives also were evaluated qualitatively for potential effects on Chinook salmon adult immigration (see Section G-AQUA1.8.1 of Appendix G-AQUA1 of the PDEA), and Chinook salmon juvenile rearing and downstream movement (see Section G-AQUA1.8.4 of Appendix G-AQUA1 of the PDEA). The analysis focused on determining the relative changes to fish habitat with respect to water depth, water velocity, and the amount of inundated habitat area compared to the known fish distribution and relative abundance.

C1.4.1.2 Water Temperature–Related Effects

Increased flows in the LFC during the initial new license operating period associated with implementation of the Proposed Project or FERC Staff Alternative would result in lower water temperatures throughout the LFC during all months of the year. Additionally, because net releases from the Oroville Facilities do not change with implementation of the Proposed Project or FERC Staff Alternative, the LFC would be contributing a higher proportion of the total flow in the lower Feather River downstream of the Thermalito Afterbay Outlet. Therefore, slightly lower water temperatures can be expected to propagate farther downstream than under existing conditions or the No-Project Alternative. The potential effects of lower water temperatures in the lower Feather River on Chinook salmon are described by life stage in the sections below. The effects analyses utilize information obtained from the detailed quantitative analysis completed for the PDEA and include a qualitative extension of that analysis to include the new colder water temperature requirements incorporated in the Proposed Project and the FERC Staff Alternative.

Adult Immigration and Holding (Spring-run, March through August; Fall-run, September through November)

After spending 3 to 4 years in the ocean, Chinook salmon begin their return to fresh water to spawn (Moyle 2002). Chinook salmon show considerable temporal variation in the timing of their spawning migrations; this life history variation is evident in the classification of Chinook salmon by run type (i.e., fall-run, late fall–run, winter-run, and spring-run). In the Central Valley, adult spring-run Chinook salmon generally migrate upstream from March to September, and individuals exhibiting fall-run life history characteristics migrate upstream from June to December (Fisher 1994). The holding period extends from the time that adult Chinook salmon enter their natal streams until the onset of spawning site selection. On the Feather River, the entire adult immigration and holding period lasts from March through October for spring-run Chinook salmon and from mid-July through December for fall-run Chinook salmon (Moyle 2002; DWR 2004c; Eaves 1982; Sommer et al. 2001).

Water temperature is an important factor in determining suitable habitat for adult Chinook salmon immigration and holding. To sufficiently protect pre-spawning fish, water temperatures that provide high adult survival and high egg viability must be available throughout the entire pre-spawning freshwater period. Although studies examining the effects of thermal stress on immigrating Chinook salmon are few, it has been demonstrated that thermal stress during the upstream spawning migration of sockeye salmon negatively affected the secretion of hormones controlling sexual maturation, causing numerous reproductive difficulties (Macdonald et al. in McCullough et al. 2001).

Potential water temperature effects that could occur during the Chinook salmon adult immigration and holding life stage are evaluated qualitatively utilizing information obtained from the analysis conducted for the PDEA, new temperature requirements associated with implementation of the Proposed Project and FERC Staff Alternative, and review of available literature.

Adult Spawning and Embryo Incubation (September through mid-February)

In the Sacramento River basin, spring-run Chinook salmon spawn from late August to October and individuals exhibiting fall-run life history characteristics spawn from late September to December (Fisher 1994). In the Feather River, adult spawning and embryo incubation occurs from September through mid-February. The duration of embryo incubation is dependent on water temperature and can be variable (NMFS 2002). In Butte and Big Chico Creeks, emergence of spring-run Chinook salmon generally occurs from November through January (NMFS 2002). In Mill and Deer Creeks, colder water temperatures delay emergence to January through March (DFG 1998a). In the lower American River, fall-run Chinook salmon emergence generally begins in March (SWRI 2004).

The adult spawning and embryo (i.e., eggs and alevins) incubation life stage includes redd construction and egg deposition, and embryo incubation through emergence. Potential effects on the adult spawning and embryo incubation life stages are evaluated together because it is difficult to separate the effects of water temperature between life stages that are closely linked temporally. Studies elucidating how water temperature affects embryonic survival and development based on varying water temperature treatments on holding adults often report results similar to those of water temperature experiments conducted on fertilized eggs (Marine 1992; McCullough 1999; Seymour 1956; SWRI 2004).

Potential water temperature effects that could occur during the Chinook salmon adult spawning and embryo incubation life stage are evaluated qualitatively utilizing information obtained from the analysis conducted for the PDEA, new temperature requirements associated with implementation of the Proposed Project and FERC Staff Alternative, and review of available literature.

Juvenile Rearing and Downstream Movement (Spring-run, November through June; Fall-run, February through June)

The juvenile life stage is composed of fry, fingerlings, and smolts; the parr stage is included in the fingerling category. Chinook salmon are fry from the time that the juvenile leaves the gravel of the spawning redd to swim up into the water column as a free-swimming fish until skeletal development is complete, at which point it reaches the fingerling stage (Bovee et al. 1998). Chinook salmon fry make the transition to the fingerling stage at approximately 45 millimeters (mm) to 60 mm (DWR 2003; NMFS 1997; NMFS 2003). Fingerling Chinook salmon become smolts when physiological changes occur that allow juveniles to survive the transition from fresh water to salt water during seaward migration. In addition to physiological changes, morphological changes also take place during smoltification (Hoar 1988). Salmonid smolts can be distinguished from pre-smolts by their silvery appearance and relatively slim, streamlined bodies (Hoar 1988).

In the Sacramento River basin, the length of time that juvenile Chinook salmon rear in natal streams varies according to run type. Juveniles displaying spring-run (stream type) life history characteristics emerge from the spawning substrate from November to March and rear for 3 to 15 months (Fisher 1994), while juveniles displaying fall-run (ocean type) life history characteristics emerge from the spawning substrate from December to March and rear for 1 to 7 months (Fisher 1994). Recent studies from the American and Feather Rivers indicate that most juvenile Chinook salmon move downstream as fry shortly after they emerge from the spawning gravel (DWR 2002; Snider and Titus 2000). In the Sacramento River, juvenile Chinook salmon move downstream during all months, as both fry and smolts (Moyle 2002).

Water temperature is a major limiting factor for juvenile Chinook salmon because it strongly affects survival and growth. Water temperatures that are too high can be lethal or cause sublethal effects such as reduced appetite and growth, increased incidence of disease, increased metabolic costs, and decreased ability to avoid predators. Available scientific literature indicates that a similar range of water temperatures provides positive growth and high survival for Chinook salmon fry, fingerlings, and smolts. Chinook salmon juveniles reportedly rear and move downstream year-round as fry, fingerlings, or smolts, and available scientific literature indicates that a range of water temperatures that is important for fry also is important for fingerlings and smolts. Therefore, evaluation of all of the phases of the juvenile life stage together is appropriate.

Potential water temperature effects that could occur in the lower Feather River during the Chinook salmon juvenile rearing and downstream movement life stage are evaluated qualitatively utilizing information obtained from the analysis conducted for the PDEA, new temperature requirements associated with implementation of the Proposed Project and FERC Staff Alternative, and review of available literature.

C1.4.1.3 Predation-Related Effects

The high concentration of spawning salmonids in the reach of the Feather River between the Fish Barrier Dam and the Thermalito Afterbay Outlet results in a high concentration of juvenile salmonids in the reach (Seesholtz et al. 2003). Additionally, Seesholtz et al. (2003) reported that most outmigration of juvenile Chinook salmon occurs between January and March. Based on historic accounts of juvenile salmonid emigration, the current peak in the emigration period is somewhat earlier than under pre-dam conditions (Painter et al. 1977; Warner 1955). Seesholtz et al. (2003) speculate that the early emigration may be caused by competition for resources resulting from unnaturally high populations of juvenile salmonids.

Water temperature and flow changes during the initial new license operating period included as components of the Proposed Project and FERC Staff Alternative to benefit anadromous salmonids also would affect predator fish species distribution, relative abundance, feeding behavior, and consumption rates. Water temperature changes, flow changes, and actions anticipated to improve the quantity, quality, and distribution of rearing habitat for juvenile salmonids (i.e., LWD placement and side-channel habitat improvement and creation) also affect rearing behavior and duration, growth rates, predator avoidance cover availability and use, and emigration timing and behavior of juvenile Chinook salmon. The alternatives were evaluated qualitatively to determine the nature and general magnitude of potential predation-related effects on Chinook salmon juvenile rearing and downstream movement. Section G-AQUA1.11.3 of Appendix G-AQUA1 of the PDEA contains a summary report and additional information on project-related effects on salmonid predation.

C1.4.1.4 Fisheries Management–Related Effects

There would be no changes in fish stocking or reservoir coldwater fisheries management programs under the alternatives; therefore, these existing programs are not included in the evaluation of alternatives. Adaptive hatchery management practices are included in the Proposed Project and the FERC Staff Alternative, and include proposals for experimental releases of different sized juvenile fish at different times and locations, predator avoidance and cover utilization conditioning, changes to brood stock selection, disease management and screening, and other hatchery management changes. These changes in hatchery management were evaluated qualitatively for their potential effects on predation, juvenile rearing and emigration survival rates, adult immigration straying rates, genetic introgression, and the incidences of fish diseases. Section G-AQUA1.5.1 of Appendix G-AQUA1 of the PDEA contains additional information related to salmonid management–related effects.

Fishing Regulations

Increases in recreation-related access, including increases in visitation and fisheries-related use of recreational resources, are anticipated under all of the alternatives. Chapter 3.0 of the DEIR, Description of Existing Facilities and Operations, the Proposed Project, and Alternatives, contains descriptions of recreation-related changes included in each of the alternatives, and Section 5.7, Recreational Resources, contains evaluations of recreation-related effects. Effects of increased recreational fishing and poaching on angling-related mortality and the contribution to adult pre-spawning mortality rates were evaluated qualitatively to determine the effects on fisheries resources, and specifically, on Chinook salmon.

Fish segregation weirs for Chinook salmon are included in the Proposed Project and the FERC Staff Alternative, and are described in detail in Chapter 3.0, Description of Existing Facilities and Operations, the Proposed Project, and Alternatives. These actions would result in changes in fishing regulations. Therefore, placement of weirs was evaluated qualitatively to determine the effects on fishing take limits and poaching. Effects on recreational activities resulting from changes in fishing regulations associated with these actions are included in Section 5.7, Recreational Resources.

C1.4.1.5 Future Facility Modification Effects

Potential future facility modifications to meet water temperature objectives in the LFC and HFC are listed in Section C1.3.10, above. Potential effects of any of the future facility modifications that are currently under study on Chinook salmon are evaluated qualitatively, relative to the potential water temperature effects of the Proposed Project and FERC Staff Alternative on Chinook salmon during the initial new license operating period.

C1.4.2 Steelhead/Rainbow Trout

Similar to the Chinook salmon analyses, the steelhead effects analysis is based upon individual life stages, because each life stage has specific flow and water temperature requirements. The steelhead life stages included in this analysis are:

- Adult immigration and holding (September through April 15);
- Adult spawning and embryo incubation (December through May);
- Fry and fingerling rearing and downstream movement (year-round); and
- Smolt emigration (January through June).

More detailed descriptions of steelhead life stages and periods are provided in Section 4.4.2, Fish Species Overview.

C1.4.2.1 Flow-Related Effects

Qualitative analyses of the alternatives were conducted for steelhead adult spawning and embryo incubation using the available WUA-discharge relationship of flow to steelhead spawning habitat availability for the LFC and HFC in the lower Feather River. Section C1.4.1 of this appendix provides additional detail describing the PHABSIM analysis conducted; Figures C1.4-1 and C1.4-2 show the steelhead WUA index curves for the LFC and HFC, respectively.

Analysis of available spawning area using PHABSIM model results does not provide information regarding the potential for stage reductions during the embryo incubation portion of the adult spawning and embryo incubation life stage. Flows under the alternatives would remain constant in the LFC, however, and would fluctuate within the minimum flow and maximum flow agreed upon by DFG and DWR in the HFC; therefore, further analysis of flow fluctuations in the LFC or HFC is unnecessary.

Flow changes and flow fluctuations associated with the alternatives were evaluated qualitatively for potential effects on steelhead/rainbow trout adult immigration and holding, steelhead/rainbow trout fry and fingerling rearing and downstream movement, and steelhead smolt emigration. The objective of this analysis was to determine the relative changes to available habitat with respect to water depth, water velocity, and the amount of inundated habitat area compared to the known fish distribution and relative abundance.

C1.4.2.2 Water Temperature–Related Effects

Increased flows in the LFC associated with implementation of the Proposed Project or FERC Staff Alternative would result in lower water temperatures throughout the LFC during all months of the year. Additionally, because net releases from the Oroville Facilities do not change with implementation of the Proposed Project or FERC Staff Alternative, the LFC would be contributing a higher proportion of the total flow in the lower Feather River downstream of the Thermalito Afterbay Outlet. Therefore, slightly lower water temperatures can be expected to propagate further downstream than under Existing Conditions or the No-Project Alternative. The potential effects of lower water temperatures in the lower Feather River on steelhead are described by life stage in the sections below. The effects analysis will utilize information obtained from the detailed quantitative analysis completed for the PDEA and include a qualitative extension of that analysis to include the new colder water temperature requirements incorporated in the Proposed Project and the FERC Staff Alternative.

Adult Immigration and Holding (September through April 15)

Most Central Valley steelhead spend 1 to 2 years in the ocean before entering fresh water beginning during August, with a peak in late September to October. Steelhead then hold in fresh water until spawning. Movement of adult steelhead from freshwater holding areas to spawning grounds generally can occur any time from December to March, with peak activities occurring in January and February (Moyle 2002). In the

Feather River, the adult immigration and holding time period lasts from September through mid-April, with peak migration extending from October through November (Moyle 2002; Cavallo, pers. comm. 2004; McEwan 2001; S. P. Cramer & Associates 1995).

The adult immigration and adult holding life stages are evaluated together in this subsection because it is difficult to determine the thermal regime to which steelhead have been exposed before spawning. Additionally, to be sufficiently protective of pre-spawning fish, water temperatures that provide high adult survival and high in-vivo egg survival must be available throughout the entire pre-spawning freshwater period. Although there is a paucity of studies examining the effects of thermal stress on immigrating steelhead, it has been demonstrated that thermal stress during the upstream spawning migration of sockeye salmon negatively affected the secretion of hormones controlling sexual maturation, causing numerous reproductive impairments (Macdonald et al. in McCullough et al. 2001).

Potential water temperature effects that could occur during the steelhead adult immigration and holding life stage are evaluated qualitatively utilizing information obtained from the analysis conducted for the PDEA, new temperature requirements associated with implementation of the Proposed Project and FERC Staff Alternative, and review of available literature.

Adult Spawning and Embryo Incubation (December through May)

Steelhead spawning includes the time period from redd construction until spawning is completed with the deposition and fertilization of eggs. The embryo incubation period extends from egg deposition through alevin emergence. In the Central Valley, steelhead spawning reportedly occurs from October through June (McEwan 2001) and embryo (i.e., eggs and alevins) incubation generally lasts 2 to 3 months after deposition (Moyle 2002; McEwan 2001; Myrick and Cech 2001). In the Feather River, steelhead spawning and embryo incubation extends from December through May, with peak spawning occurring in January and February (Moyle 2002; Busby et al. 1996; Cavallo, pers. comm. 2004; Interagency Ecological Program Steelhead Project Work Team Website 1998). As with Chinook salmon, the steelhead embryo life stage is the most sensitive to water temperature.

Potential water temperature effects that could occur during the steelhead adult spawning and embryo incubation life stage are evaluated qualitatively utilizing information obtained from the analysis conducted for the PDEA, new temperature requirements associated with implementation of the Proposed Project and FERC Staff Alternative, and review of available literature.

Fry and Fingerling Rearing and Downstream Movement (Year-round)

The juvenile life stage is composed of fry and fingerlings. Steelhead are fry from the time that the juvenile leaves the gravel of the spawning redd to swim up into the water column as a free-swimming fish until skeletal development is complete, at which point it reaches the fingerling stage (Bovee et al. 1998). Steelhead fry make the transition to the fingerling stage at approximately 45 mm to 60 mm (Moyle 2002; Bovee et al. 1998; DWR 2003; NMFS 1997). After Central Valley steelhead emerge from the gravel, juveniles remain in fresh water for 1 to 3 years before smolting and migrating to salt water (Myrick and Cech 2001).

Potential water temperature effects that could occur during the steelhead fry and fingerling rearing and downstream movement life stage are evaluated qualitatively utilizing information obtained from the analysis conducted for the PDEA, new temperature requirements associated with implementation of the Proposed Project and FERC Staff Alternative, and review of available literature.

Smolt Emigration (January through June)

Fingerling steelhead become smolts when physiological changes occur that allow the juvenile to survive the transition from fresh water to salt water during seaward migration. In addition to physiological changes, morphological changes also take place during smoltification (Hoar 1988). Salmonid smolts can be distinguished from pre-smolts by their silvery appearance and relatively slim, streamlined bodies (Hoar 1988). Steelhead smolts migrate out to sea between 1 and 3 years of age, between 10 and 25 centimeters (cm) fork length (FL) (Moyle 2002). In the Feather River, steelhead smolt emigration occurs from January through June (Cavallo, pers. comm. 2004; McEwan 2001; Newcomb and Coon 2001; Snider and Titus 2000; USFWS 1995).

Potential water temperature effects that could occur during the steelhead smolt emigration life stage are evaluated qualitatively utilizing information obtained from the analysis conducted for the PDEA, new temperature requirements associated with implementation of the Proposed Project and FERC Staff Alternative, and literature review.

C1.4.2.3 Predation-Related Effects

The high concentration of spawning salmonids in the LFC results in a high concentration of juvenile salmonids (Seesholtz et al. 2003). In addition, water temperature and flow changes included as components of the alternatives to benefit anadromous salmonids also would affect predator fish species distribution, relative abundance, feeding behavior, and consumption rates. Water temperature changes, flow changes, and actions anticipated to improve the quantity, quality, and distribution of rearing habitat for juvenile salmonids (LWD placement and side-channel habitat improvement and creation) also affect steelhead fry and fingerling rearing behavior and distribution, growth rates, predator avoidance cover availability and use, and smolt emigration timing and behavior. The alternatives were evaluated qualitatively to determine the nature and general magnitude of potential predation-related effects on rearing and downstream movement by steelhead fry and fingerlings. Section G-AQUA1.11.3 of Appendix G-AQUA1 of the PDEA contains additional information related to salmonid predation.

C1.4.2.4 Fisheries Management–Related Effects

There would be no changes in fish stocking or reservoir fisheries habitat enhancement programs under the alternatives; therefore, these programs are not included in the evaluation of alternatives. Adaptive hatchery management practices are included in the Proposed Project and the FERC Staff Alternative and include proposals for experimental releases of different sized juvenile fish at different times and locations, predator avoidance and cover utilization conditioning, changes to brood stock selection, disease management and screening, and other hatchery management changes. These changes in hatchery management were evaluated qualitatively for their potential effects on predation, juvenile rearing and emigration survival rates, adult immigration straying rates, genetic introgression, and the incidences of fish diseases. Section G-AQUA1.5.1 of Appendix G-AQUA1 of the PDEA contains additional information related to the effects of salmonid management on Feather River fishes.

Fishing Regulations

Increases in recreation-related access, including increases in visitation and fisheries-related use of recreational resources, are anticipated under all of the alternatives. Chapter 3.0, Description of the Existing Facilities and Operations, the Proposed Project, and Alternatives, contains descriptions of recreation-related changes included in each of the alternatives; Section 5.7, Recreational Resources, contains evaluations of recreation-related effects. Effects of increased recreational fishing and poaching on angling-related mortality and the contribution to adult pre-spawning mortality rates were evaluated qualitatively to determine effects on fisheries resources, and specifically, on steelhead.

Fish segregation weirs for Chinook salmon are included in the Proposed Project and the FERC Staff Alternative, and are described in detail in Chapter 3.0, Description of Existing Facilities and Operations, the Proposed Project, and Alternatives. These actions would result in changes in fishing regulations. Therefore, placement of weirs was evaluated qualitatively to determine their effects on fishing take limits and poaching. Effects on recreational activities resulting from changes in fishing regulations associated with these actions are described in Section 5.7, Recreational Resources.

C1.4.2.5 Future Facility Modification Effects

Potential future facility modifications to meet new SA water temperature objectives in the LFC and HFC are listed in Section C1.3.10, above. Potential effects of each of the potential facility modifications currently being studied on steelhead are evaluated qualitatively, relative to the potential water temperature effects of the Proposed Project and FERC Staff Alternative on steelhead during the initial new license operating period.

C1.4.3 American Shad

C1.4.3.1 Flow-Related Effects

Flow changes and flow fluctuations associated with the alternatives were evaluated qualitatively to determine the potential effects on American shad adult immigration and spawning based on the relative changes to fish habitat with regard to water depth, water velocity, and fish passage impediments compared to the known fish distribution and relative abundance. The American shad spawning migration period in the Feather River occurs from April through June. Sections G-AQUA1.4.2 and G-AQUA1.4.3 of Appendix G-AQUA1 of the PDEA provide additional information on American shad immigration and potential flow-related passage impediments in the lower Feather River.

C1.4.3.2 Water Temperature–Related Effects

Water temperature–related effects were evaluated qualitatively using the process described in Section C1.2.3 of this appendix. The water temperature range reported to be suitable for American shad adult immigration and spawning is 46°F to 79°F, and this life stage occurs from April through June in the lower Feather River (Moyle 2002; DFG 1986; Leggett and Whitney 1972; Painter et al. 1979; USFWS 1995; Walburg and Nichols 1967; Wang 1986).

The water temperature analysis for American shad habitat qualitatively compares the relative decreases in lower Feather River water temperatures expected with implementation of the Proposed Project or FERC Staff Alternative with current conditions and the No-Project Alternative during the life stage period evaluated. Section 4.4.2 of the DEIR, Fish Species Overview, and Section G-AQUA1.4.2 of Appendix G-AQUA1 of the PDEA provide additional information on American shad life history, and habitat and water temperature requirements.

C1.4.3.3 Future Facility Modification Effects

Potential future facility modifications to meet new SA water temperature objectives in the LFC and HFC are listed in Section C1.3.10, above. The effects that could occur as a result of potential future facility modifications on American shad also are evaluated qualitatively, relative to the potential water temperature effects of the Proposed Project and FERC Staff Alternative on American shad during the initial new license operating period.

C1.4.4 Black Bass

C1.4.4.1 Water Temperature–Related Effects

The water temperature analysis for black bass habitat qualitatively compares the relative decreases in lower Feather River water temperatures expected with implementation of the Proposed Project or FERC Staff Alternative with current conditions and the No-Project Alternative during the life stage period evaluated. The black bass analysis includes several fish species with similar water temperature requirements, including largemouth bass, smallmouth bass, redeye bass, and spotted bass. Section 4.4.2, Fish Species Overview, of the DEIR and Sections G-AQUA1.4.2, G-AQUA1.3.2, and G-AQUA1.3.4 of Appendix G-AQUA1 of the PDEA contain additional information on black bass life history, and habitat and water temperature requirements.

C1.4.4.2 Future Facility Modification Effects

Potential future facility modifications that are being studied to determine their effectiveness in meeting new SA water temperature objectives in the LFC and HFC are listed in Section C1.3.10, above. Potential effects of future facility modifications on black bass are evaluated qualitatively, relative to the potential water temperature effects of the Proposed Project and FERC Staff Alternative on black bass during the initial new license operating period.

C1.4.5 Green Sturgeon

The analysis of potential effects on green sturgeon is based upon individual life stages because each life stage has specific flow and water temperature requirements. The green sturgeon life stages included in this analysis are:

- Adult immigration and holding (February through July);
- Adult spawning and embryo incubation (March through July);
- Juvenile rearing (year-round); and
- Juvenile emigration (May through September).

More detailed descriptions of green sturgeon life stage water temperature requirements and periods are provided in Section 4.4.2, Fish Species Overview, of the DEIR and Section G-AQUA1.4.2 of Appendix G-AQUA1 of the PDEA.

C1.4.5.1 Water Temperature–Related Effects

Water temperature–related effects were evaluated using the process described in Section C1.2.3 of this appendix. The water temperature analysis for green sturgeon is based on the expected water temperature decreases associated with implementation of the Proposed Project or the FERC Staff Alternative.

Adult Immigration and Holding (February through July)

Water temperatures ranging from 44°F to 61°F are reported as "preferred," "optimal," "suitable," or "observed" for green sturgeon adult immigration and holding (Beamesderfer and Webb 2002; DFG Leetet al. 2001; DFG Website 2002; Emmett et al. 1991; Environmental Protection Information Center et al. 2001d; Erickson et al. 2002; USFWS 1995). The range of reported water temperatures was used as an evaluation guideline to qualitatively assess the potential effects of each alternative on green sturgeon adult immigration and holding, relative to the basis of comparison.

Adult Spawning and Embryo Incubation (March through July)

Water temperatures ranging from 46°F to 68°F are reported as “preferred,” “optimal,” “suitable,” or “observed” for green sturgeon adult spawning and embryo incubation (Artyukhin and Andronov 1990; Beamesderfer and Webb 2002; DFG Leetet al. 2001; DFG Website 2002; Cech et al. 2000; Environmental Protection Information Center et al. 2001c; Erickson et al. 2002; Moyle et al. 1995; USFWS 1995). The range of reported water temperatures was used as an evaluation guideline to qualitatively assess the potential effects of each alternative on green sturgeon adult spawning and embryo incubation, relative to the basis of comparison.

Juvenile Rearing (Year-round)

Water temperatures ranging from 50°F to 66°F are reported as “preferred,” “optimal,” “suitable,” or “observed” for green sturgeon juvenile rearing (Moyle 2002; Cech et al. 2000; Conservation Management Institute Website 1996; Environmental Protection Information Center et al. 2001b; Farr et al. 2001). The range of reported water temperatures was used as an evaluation guideline to qualitatively assess the potential effects of each alternative on green sturgeon juvenile rearing, relative to the basis of comparison.

Juvenile Emigration (May through September)

Water temperatures ranging from 50°F to 66°F are reported as “preferred,” “optimal,” “suitable,” or “observed” for green sturgeon juvenile emigration (Moyle 2002; Adams et al. 2002; Beamesderfer and Webb 2002; Cech et al. 2000; Conservation Management Institute Website 1996; Environmental Protection Information Center et al. 2001a; Erickson et al. 2002; Farr et al. 2001). The range of reported water temperatures was used as an evaluation guideline to qualitatively assess the potential effects of each alternative on green sturgeon juvenile emigration, relative to the basis of comparison.

C1.4.5.2 Future Facility Modification Effects

Potential future facility modifications being studied to meet new water temperature objectives in the LFC and HFC are listed in Section C1.3.10, above. Potential effects of future facility modifications on green sturgeon are evaluated qualitatively, relative to the potential water temperature effects of the Proposed Project and FERC Staff Alternative on green sturgeon during the initial new license operating period.

C1.4.6 Hardhead

C1.4.6.1 Water Temperature–Related Effects

Water temperature–related effects were evaluated using the process described in Section C1.2.3 of this appendix. The water temperature range reported as suitable for hardhead adult spawning is 55°F to 75°F, and this life stage occurs from April through August in the lower Feather River (Moyle 2002; Cech Jr. et al. 1990; Wang 1986). The water temperature analysis for hardhead is based on the expected water temperature decreases associated with implementation of the Proposed Project or the FERC Staff Alternative.

C1.4.6.2 Future Facility Modification Effects

Potential future facility modifications being studied to meet new SA water temperature objectives in the LFC and HFC are listed in Section C1.3.10, above. Potential effects of future facility modifications on Hardhead are evaluated qualitatively, relative to the potential water temperature effects of the Proposed Project and FERC Staff Alternative on hardhead during the initial new license operating period.

C1.4.7 River Lamprey

C1.4.7.1 Water Temperature–Related Effects

Water temperature–related effects were evaluated using the process described in Section C1.2.3 of this appendix. The water temperature range reported as suitable for river lamprey adult spawning and embryo incubation is 43°F to 72°F, and this life stage reportedly occurs from April through June in the lower Feather River (Moyle 2002; Beamish 1980; Kostow 2002; Meeuwig et al. 2003; Meeuwig et al. 2002; Stone et al. 2001; Wang 1986). Because little literature was available regarding the life stage timing and water temperature tolerance range of river lamprey, literature describing Pacific lamprey (*Lampetra tridentata)* was used because several of the species life history and behavioral characteristics reportedly are similar. The water temperature analysis for river lamprey is based on the expected water temperature decreases associated with implementation of the Proposed Project or the FERC Staff Alternative.

C1.4.1.5 Future Facility Modification Effects

Potential future facility modifications being studied to meet new SA water temperature objectives in the LFC and HFC are listed in Section C1.3.10 above. Potential effects of future facility modifications on river lamprey are evaluated qualitatively, relative to potential water temperature effects of the Proposed Project and FERC Staff Alternative on river lamprey during the initial new license operating period.

C1.4.8 Sacramento Splittail

C1.4.8.1 Water Temperature–Related Effects

Water temperature–related effects were evaluated using the process described in Section C1.2.3 of this appendix. The water temperature range reported as suitable Sacramento splittail adult spawning, egg incubation, and initial rearing is 45°F to 75°F, and this life stage occurs from February through May in the lower Feather River. Young (1996) investigated thermal tolerances for juvenile splittail and reported a tolerance range of 7°C to 32°C (44.6°F to 89.6°F). Caywood (1974) reported splittail spawning in water temperatures from 9°C to 20°C (48.2°F to 68.0°F). Sommer et al. (2002) reported splittail spawning in water temperatures from 11°C to 24°C (51.8°F to 75.2°F). The water temperature analysis for splittail habitat qualitatively evaluates potential effects of lower water temperatures anticipated with implementation of the Proposed Project or FERC Staff Alternative during the life stage period evaluated.

C1.4.8.2 Future Facility Modification Effects

Potential future facility modifications being studied to meet new SA water temperature objectives in the LFC and HFC are listed in Section C1.3.10 above. Potential effects of the facility modifications on Sacramento splittail are evaluated qualitatively, relative to the potential water temperature effects of the Proposed Project and FERC Staff Alternative on Sacramento splittail during the initial new license operating period.

C1.4.9 Striped Bass

C1.4.9.1 Flow-Related Effects

Flow changes and flow fluctuations associated with the alternatives were evaluated qualitatively to assess potential effects on striped bass adult spawning habitat with regard to water depth, water velocity, and fish passage impediments compared to the known fish distribution and relative abundance. The striped bass adult spawning period in the lower Feather River occurs from April through June. Section 4.4.2 of the DEIR, Fish Species Overview, and Section G-AQUA1.4.2 of Appendix G-AQUA1 of the PDEA provide additional information on striped bass adult spawning, egg incubation, initial rearing, and life history habitat requirements.

C1.4.9.2 Water Temperature–Related Effects

Water temperature–related effects were evaluated using the process described in Section C1.2.3 of this appendix. The water temperature range reported as suitable for striped bass adult spawning is 59°F to 68°F, and this life stage occurs from April through June in the lower Feather River (Moyle 2002; Bell 1991; Hassler 1988; Hill et al. 1989). The water temperature analysis for striped bass adult spawning is qualitative and based on anticipated cooler water temperatures associated with implementation of the Proposed Project or the FERC Staff Alternative during the life stage period evaluated.

C1.4.9.3 Future Facility Modification Effects

Potential future facility modifications being studied to meet new SA water temperature objectives in the LFC and HFC are listed in Section C1.3.10, above. Potential effects of future facility modifications on striped bass are evaluated qualitatively, relative to the potential water temperature effects of the Proposed Project and FERC Staff Alternative on striped bass during the initial new license operating period.

C1.5 DETERMINATION OF EFFECTS

The evaluation process for determining potential effects resulting from implementation of the alternatives was based on the integration of the effects identified for each species and life stage selected for evaluation. The results of the qualitative evaluation of potential effects on each life stage were aggregated and evaluated to determine the overall effect of an alternative on a species. Positive and negative effects on the species and life stages were evaluated using professional experience and judgment to weigh the relative magnitude, biological effects, and importance of a life stage in contributing to the overall success and condition of the species. The overall effect of an alternative on a species was the basis for the evaluation of the alternatives. Section 5.4.4 of the DEIR provides a summary of the overall effects of the alternatives on each species of primary management concern.

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